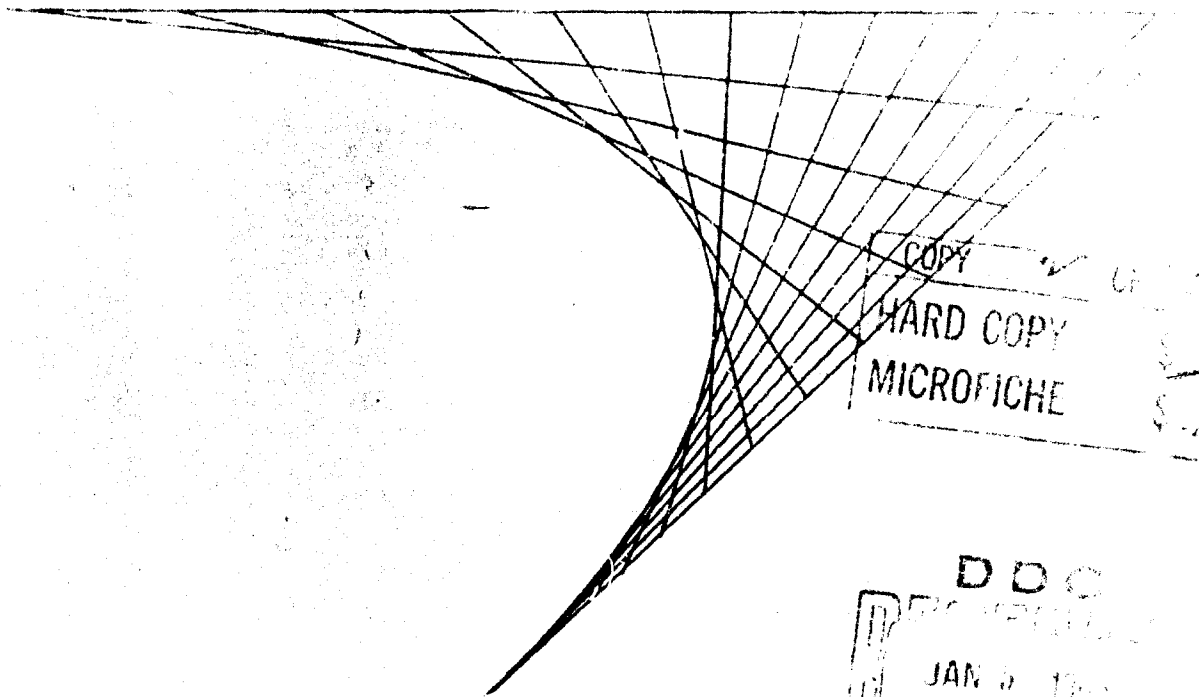


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The Eye Research Foundation *of Bethesda*

Final Report Contract Nonr 2750(00)



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Retinal Sensitivity During Photopic Adaptation

Final Report Contract Nonr 2750(00)

between

The Office of Naval Research, Department of the Navy

and

The Eye Research Foundation of Bethesda

(an affiliate of the University of Maryland)

January 1, 1965

Personnel -

**Director of Research: William M. Hart, Ph.D., M.D., Clinical
Professor of Neuro-ophthalmology, Univ. of Maryland**

Department of Biophysics -

**Chairman: Robert H. Peckham, Ph.D., Research Professor of
Physiological Optics, Univ. of Maryland**

**Associate: Carl R. Cavonius, Ph.D., Research Associate Professor,
Univ. of Maryland**

Associate and Secretary: Neva B. Peckham, B.A.

Laboratory Assistants:

John H. Gebhart, M.S.

John K. Peckham

Janet Appel, B.S.

Kasser Moradi, B.A.

The contract was established Nov. 1, 1958 and terminated Oct. 31, 1964. During those six years fourteen papers, supported in whole or part by this contract, were published or read. Bibliographical references of published papers are indicated by brackets [].

1. Final Report Contract Nonr 2750(00), "Retinal Sensitivity During Photopic Adaptation."

2. Retinal Sensitivity and Night Visibility [1].

Retinal sensitivity was estimated by flicker methods. It was shown that the distribution of sensitivity bears an inverse correlation with age. Older persons would be expected to have the poorest night driving visual ability.

3. Technical Report #1, Contract Nonr 2750(00), October 12, 1959, to the Office of Naval Research, Department of the Navy.

This report reviewed the experimental work of the first year of the contract. Eight experimental programs were established. (1) the time procedure for flicker studies; (2) the effect of the range of the stimulation frequency on estimation of the CFF threshold; (3) effect of binocular enhancement over the two monocular thresholds; (4) the reliability of CFF data showed agreement between three random sections of the data from 39 subjects, at the .9986 level by the χ^2 test; (5) the comparisons of threshold at a high and a low photopic luminance level; (6) the effect of high luminance ($16,000 \text{ cd/m}^2$) on the CFF at moderate luminance (20 cd/m^2), showed no significant difference immediately following exposure or 4 1/2 minutes later; (7) the effect of low luminance (0.3 cd/m^2) on CFF at moderate luminance (20 cd/m^2), demonstrated a violent pupillary response to the increase in luminance lasting for 7 seconds; (8) the effect of age.

3. Subthreshold Retinal Integration in Low Contrast Flicker [2].

It was shown that some integration function within the retinal synapses facilitates flicker response at a faster rate (just below average threshold) but does not affect response to slower rates (just above average threshold).

4. Neural Integration at the Retinal Level as Evidenced by Flicker Fusion Measurements [3].

Estimation of the CFF threshold depends heavily on the range of the stimuli selected to obtain the probability curve of the response. A model for neural interconnections of bipolar cells was presented.

4. The Association between Retinal Sensitivity and the Glare Problem [4].

Persons with good flicker sensitivity show better recovery from glare. In terms of highway travel at 60 MPH the glare effect varies from 300 feet to 2,500 feet.

5. Binocular Summation of Subliminal Repetitive Stimulation [5].

When monocular thresholds for CFF are estimated from sigmoid distribution curves, the binocular prediction $Q_R \times Q_L = Q_B$ falls short of the actual binocular achievement.

6. Synaptic Behavior as Deduced from Thresholds to Reversing Visual Stimuli [6].

The study of Binocular Summation was repeated using subjects with dilated pupils. It was concluded that binocular enhancement must have a post-chiasmatal origin.

7. Geometric Analysis of the Corneal ECG for Shortened ON and OFF Stimuli. Third Physiological Psychology Symposium, Naval Air Station, Pensacola, Fla., March 1962.

A preliminary presentation of items 9 and 14. [7] and [10]

8. The Geometrical Analysis of Photopic Corneal ECG [7].

It was shown that a combination of normal and log-normal distribution curves quite exactly describes the relation between voltage and time for a single flash ECG on frogs. The a-wave of an AC amplified ECG follows the course of a normal distribution, and the b-wave and the off-effect follow log-normal distributions. It was conjectured that the a-wave could be the accumulating responses of the photo-sensitive cells, and that the b-wave and off-effect could be of chemical origin in the bipolar synapses.

10. Independence and Interdependence in ON and OFF Visual Stimuli [8].

When retinal stimulation is presented as ON-ON-ON (brighter and brighter), or OFF-OFF-OFF (dimmer and dimmer) the ECG shows for step-wise ON's successive a-waves and b-waves and shows for step-wise OFF's successive OFF-effects. The a- and b-waves are independent of the OFF-effect, which in turn is independent of the a- and b-waves. Since flicker stimulation always alternates ON and OFF, CFF becomes a record of retinal adaptation within the duty cycles of the stimulation and is therefore a measure of retinal metabolism.

13. A Retroreflective Visual Signal for Night Driving Warning Devices [9].

With human subjects, when brightness difference between ON and OFF is described AB/B , and duty cycle or temporal contrast as AT/T , at certain flicker frequencies a maximum perceptual sensitivity can be established in terms of brightness and temporal contrast. At 5 cycles per second, and temporal contrast at 10%, necessary brightness contrast drops to nearly 1%. A method of presenting a retroreflective highway warning device taking advantage of this phenomenon was proposed.

14. The Geometrical Description of Electroretinograms, a paper read to the Society for Research in Ophthalmology, by Peckham, R. H., Hart, W. M., and Peckham, J. K., in June 1963 in Atlantic City, New Jersey, describing extension of reference [7], published in reference [10].

15. AC versus DC Amplification of the ERG, a paper read to the Society for Research in Ophthalmology on March 19, 1964, in Gainesville, Florida, by Peckham, R. H., Hart, W. M., and Peckham, J. K.

AC amplification creates distortion in both time and potential, including serious artifacts. AC amplification produces a distorted first derivative of the DC trace. The latent times for peak responses are fallacious, and such amplification will present an artifactual negative potential.

14. The Geometric Description of Electroretinograms [10].

When the AC-ERG's on frogs are obtained from stimuli varying in temporal contrast (duty cycle) two quite different families of curves develop for decreasingly short ON times and for decreasingly short OFF times. These can be described by normal and logarithmic-normal distribution curves. When ON time is decreased, the OFF effect disappears into the ON response, and the ERG becomes purely one of ON response. When OFF time is decreased the ERG first takes an enhanced biphasic form, but with less OFF time, the ERG tends to disappear entirely.

II. Future Extension.

The studies established by Contract Nonr 2750(00) will be continued through support from the Eye Research Foundation. These will include further study of the geometric description of ERG's on frogs, [7] and [10], using DC amplification and computer curve-fitting. Flicker

ERG's and visually evoked potentials (VEP's) are being studied especially with respect to the resonance phenomena described by Van der Tweel at the Third Symposium of the International Society for Clinical Electroretinography, October 1964.

III. References - titles given above.

- [1]. Peckham, R. H. and Hart, W. M.: Highway Research Board Bulletin #226, Nat. Acad. Sciences, Nat. Res. Council Publication 586: 1-6 (1959).
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- [3]. Peckham, R. H. and Hart, W. M.: Amer. J. Ophth., 48:594-600 (1959).
- [4]. Peckham, R. H. and Hart, W. M.: Highway Research Board Bulletin #255, Nat. Acad. Sciences, Nat. Res. Council Publication 764: 57-60 (1960).
- [5]. Peckham, R. H. and Hart, W. M.: Amer. J. Ophth., 49:1121/35-1125/39 (1960).
- [6]. Peckham, R. H. and Hart, W. M.: J. Opt. Soc. Amer., 50:512, FC14 (A), (1960).
- [7]. Peckham, R. H. and Hart, W. M.: Exp. Eye Res., 1:5-13 (1961).
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- [9]. Peckham, R. H. and Hart, W. M.: Highway Research Record, Nat. Acad. of Sciences, Nat. Res. Council Publication 1125, 83-85 (1963).
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